Energy Efficient Ventilation Systems for Dining Halls and Kitchens

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Facts

- More than 434 thousand restaurants in the US employ 12 million people throughout a year and contribute 506 trillion Btu (5.34·1017 J) to annual energy consumption.

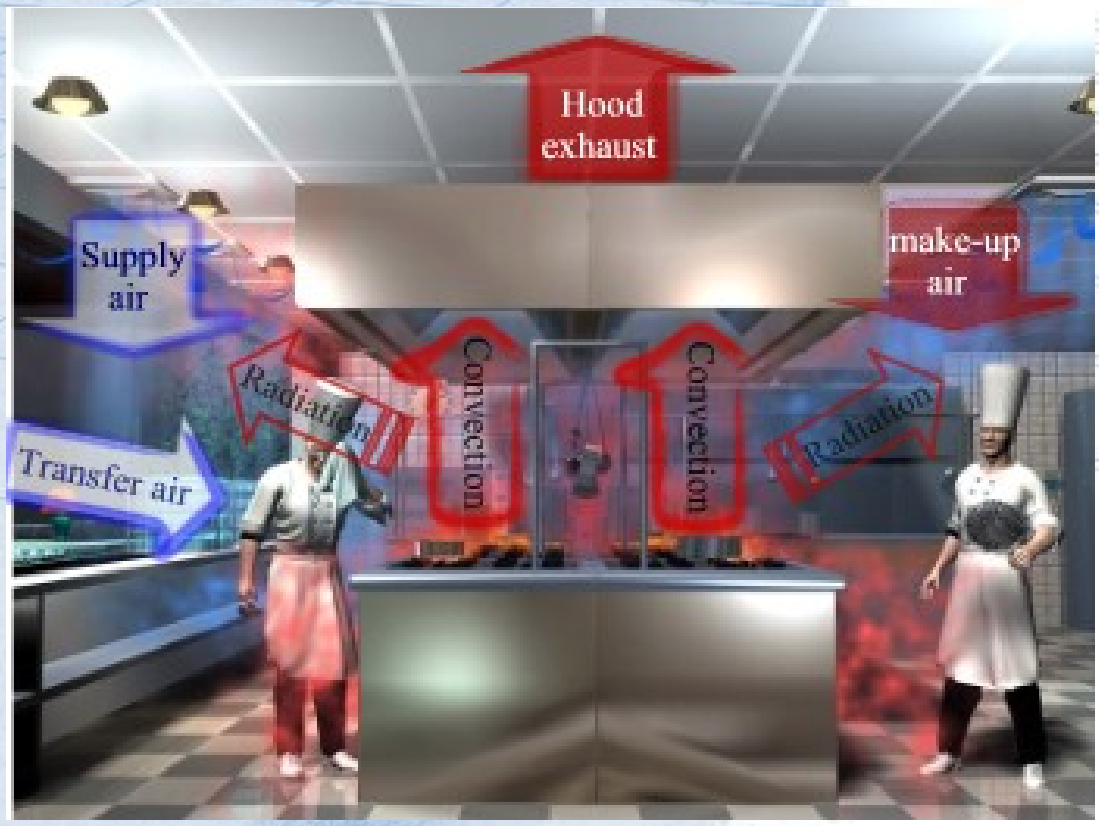
National Restaurant Association, 2004/2005 Restaurant Industry Operations Report

Facts

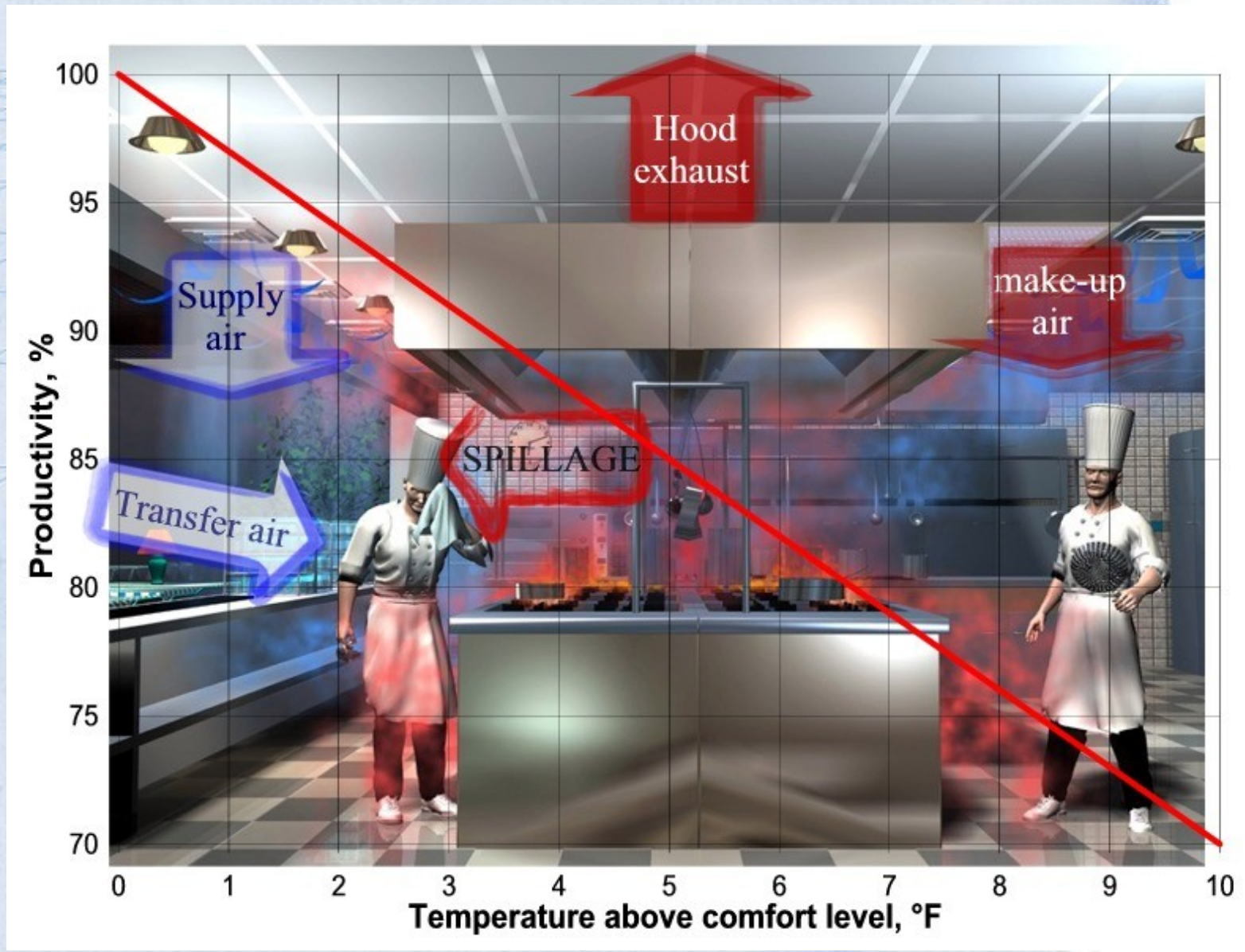
- Restaurants operate in a very competitive environment with profit margins of 5% and less.
- Only one out of five newly opened restaurants survives for five years or longer.
- Restaurant operators scramble to reduce capital investment to open a store.
- In spite of the fact that ventilation equipment is responsible for a significant portion of restaurant operating costs, it is given the last priority in the capital investment budget.

Kitchens are usually hot, why?

- Kitchen hoods not capturing convective heat from appliances
- Untempered (hot in summer) make-up air
- Undersized air conditioning system
- Radiant heat from hot appliances
  - With all other sources under control this should affect only personnel in the vicinity of the appliances

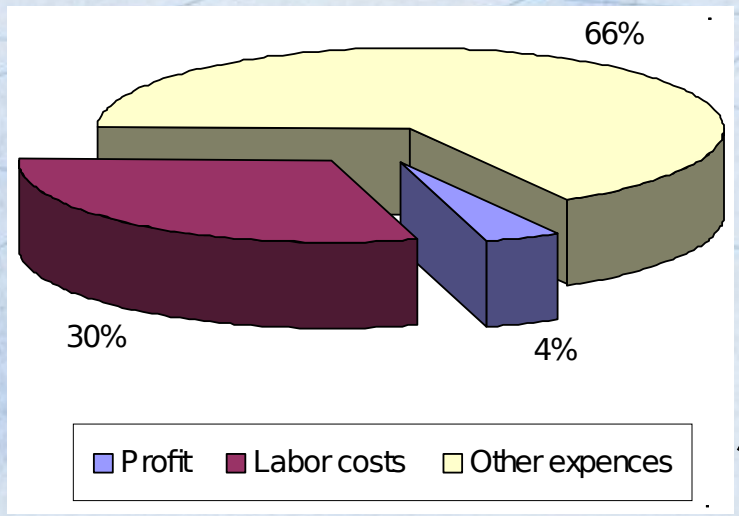


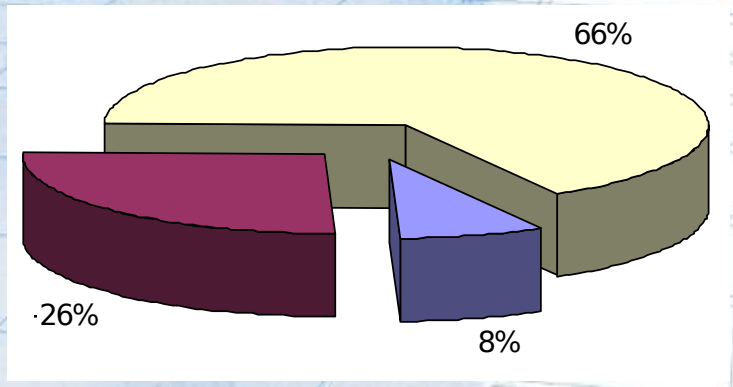
Thermal Comfort & Productivity

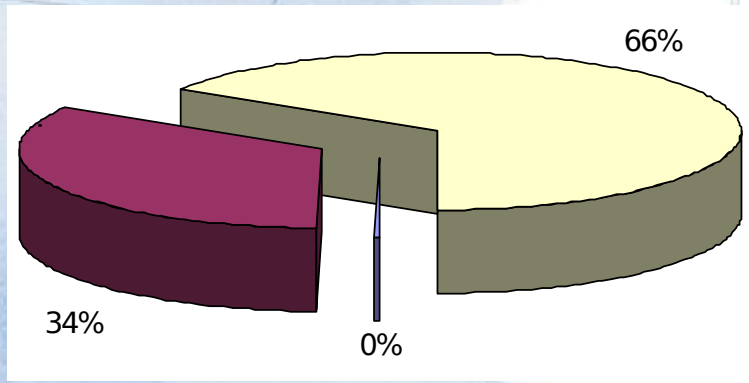


Productivity of kitchen personnel & Profitability

Productivity of kitchen personnel increased by 25%



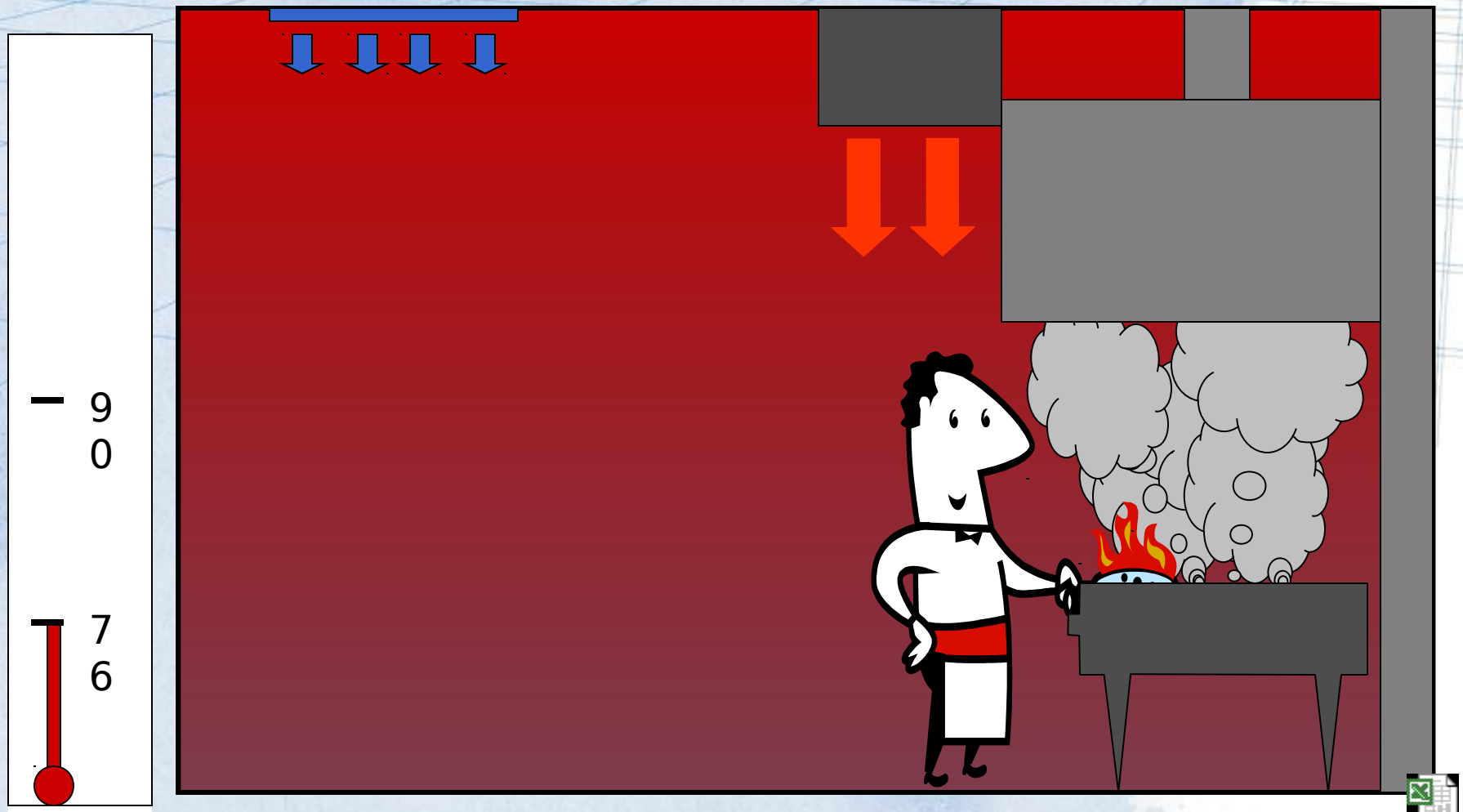




Productivity of kitchen personnel dropped by 25%

Based on data from National Restaurant Association, 2003 and assuming kitchen personnel accounts for 50% of the labor costs for the whole restaurant.

The effect of untempered make-up on kitchen temperature



Microsoft Excel Worksheet

Chicago, Jan. 2006

Kitchen hoods

- **Kitchen hoods (exhaust airflow) have the highest impact on restaurant HVAC system energy consumption.**

Annual energy consumption and CO2 emissions

per 100 cfm increase of hood exhaust airflow

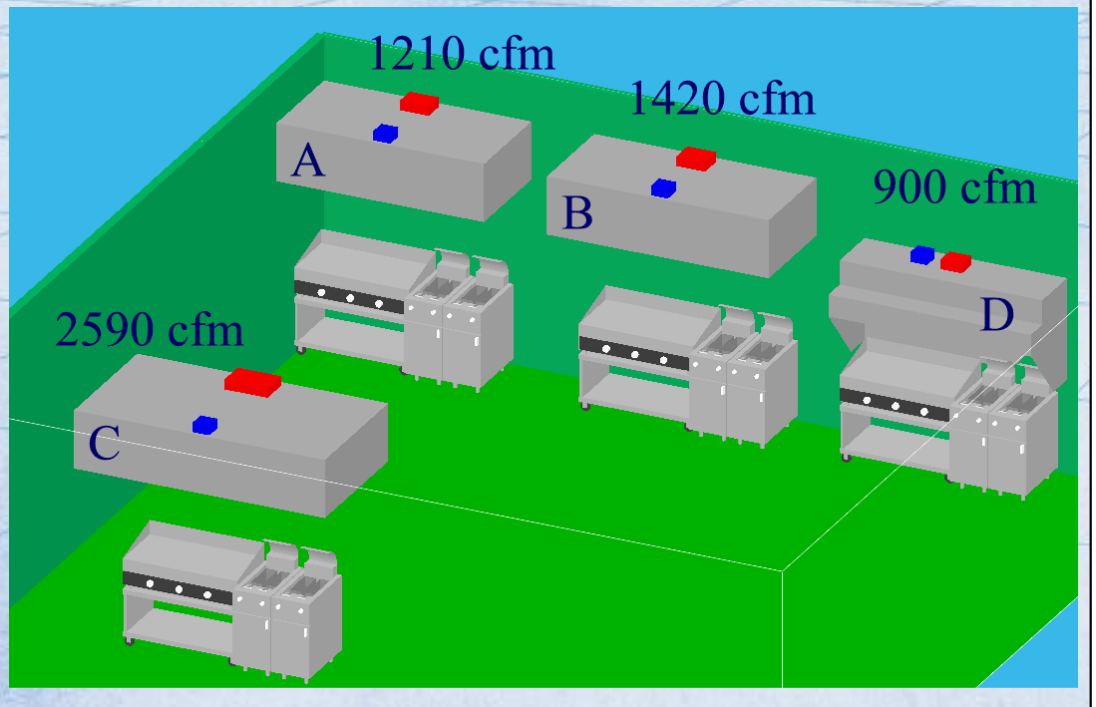
City, State	Electricity, kWh	Gas, Mln Btu	CO_2 emissions, lbs
Atlanta, GA	**373**	**1.7**	**713**
Chicago, IL	**165**	**5.6**	**852**
Las Vegas, NV	**381**	**0.6**	**656**
Los Angeles, CA	**19**	**0**	**15**
Miami, FL	**1365**	**0**	**1897**
Minneapolis, MN	**158**	**8.2**	**1201**
New York, NY	**162**	**3.8**	**588**
San Francisco, CA	**18**	**0.3**	**49**

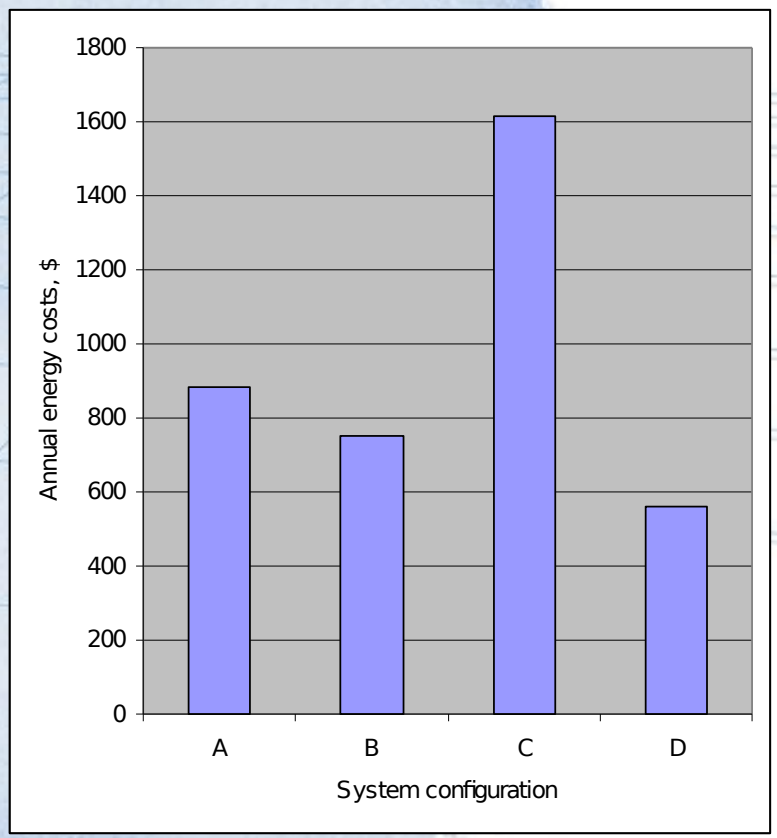
Calculation background: Restaurant operates from 7:00 AM to 11:00 PM seven days a week. Electricity consumption is calculated based on energy required to operate supply and exhaust fans to move additional 100 cfm of air and energy consumption by compressor of refrigeration system to cool outside air in summer down to kitchen indoor air conditions (76°F, 50% relative humidity). Calculation of gas consumption is based on amount of gas required to heat the make-up air in winter to 50°F. Carbon dioxide emissions to the atmosphere are calculated based on gas consumption as well as electricity consumption, using emission factor (CO2 emissions per unit of electricity produced) for corresponding city.

How to reduce hood exhaust airflow

- **Position cooking appliances close to the walls, avoid island installations when possible**
- **Enclose appliances with the walls**
- **Avoid cross-drafts in kitchen space**
- **Use low velocity air distribution**
  - Displacement ventilation allows reducing hood exhaust airflow by 15%
- **Use high efficiency, close proximity hoods**

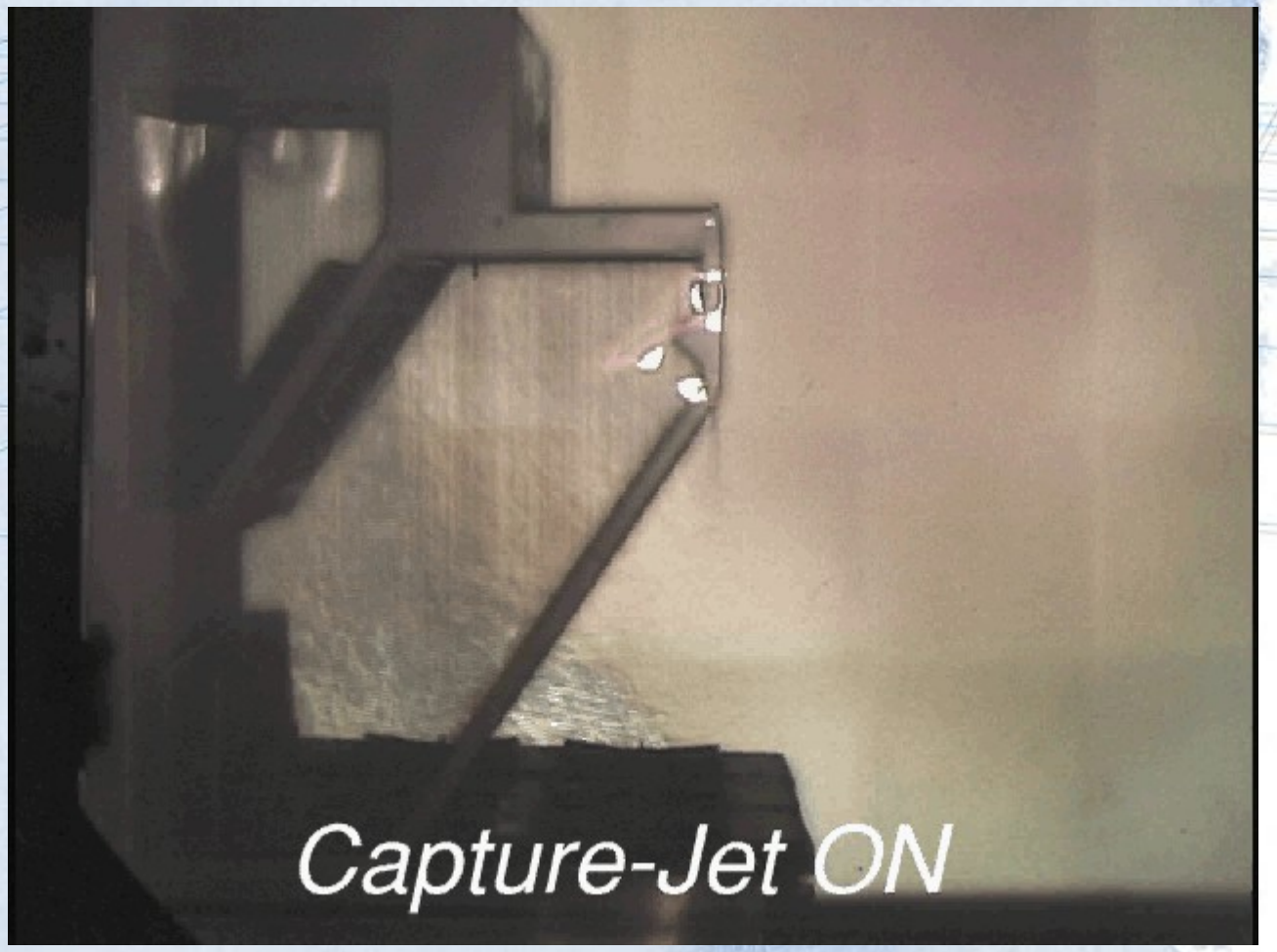
Appliance position



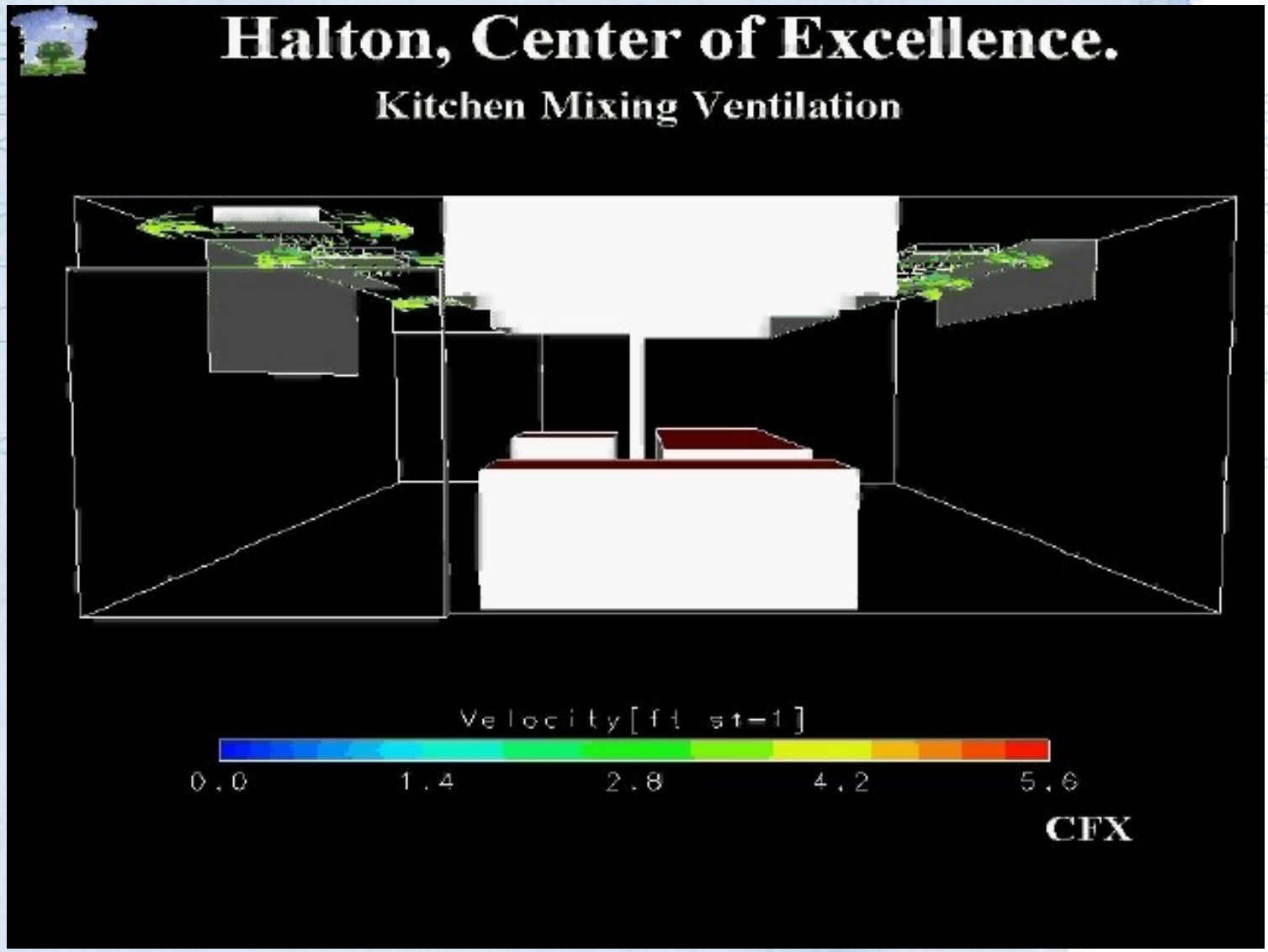


A – appliances in the corner with canopy wall hood; B – appliances at the wall with canopy wall hood; C – appliances in the middle of the space with canopy island hood; D – appliances at the wall with close proximity back-shelf hood.

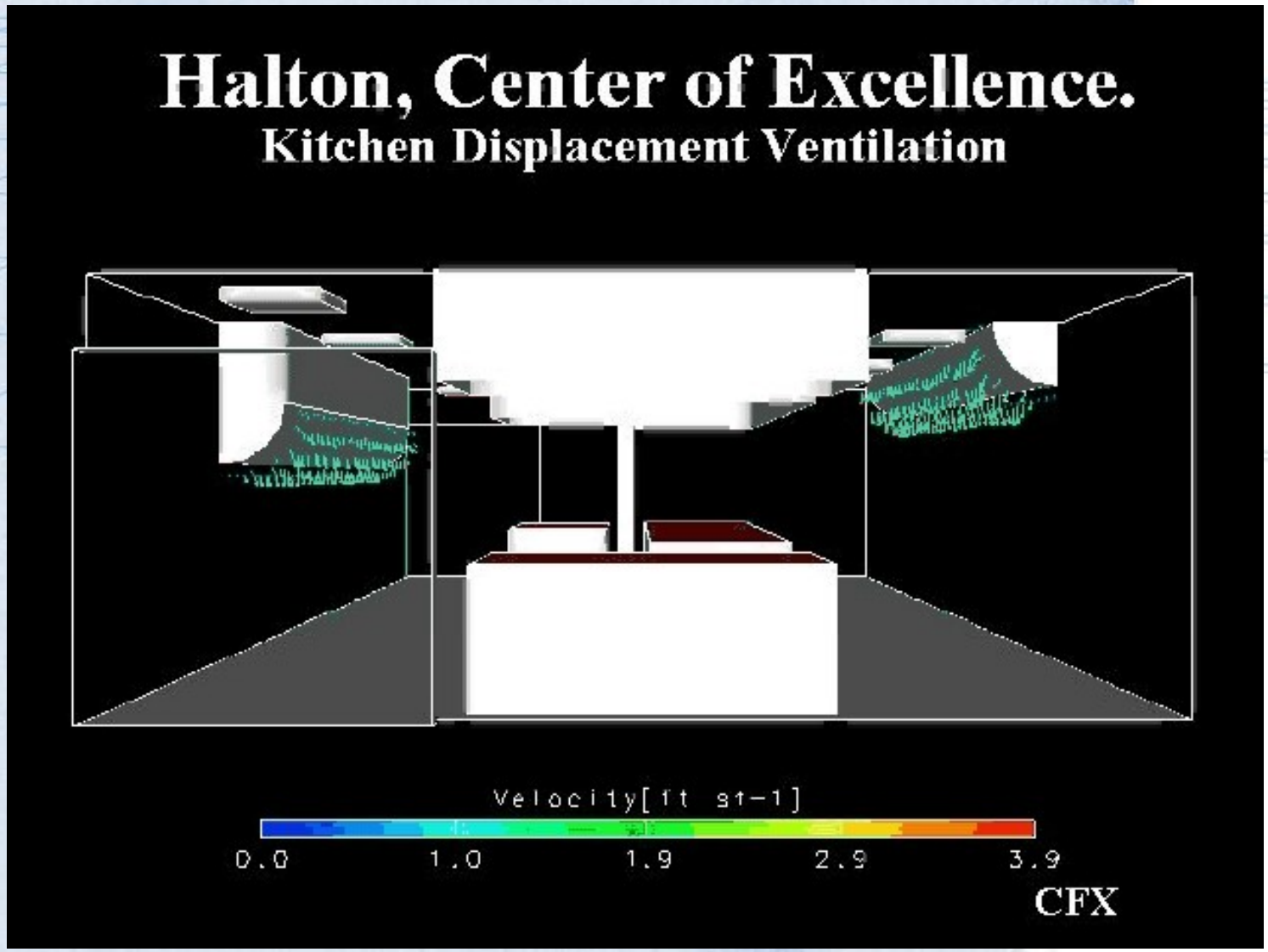
High efficiency hoods



Mixing ventilation, CFD simulation



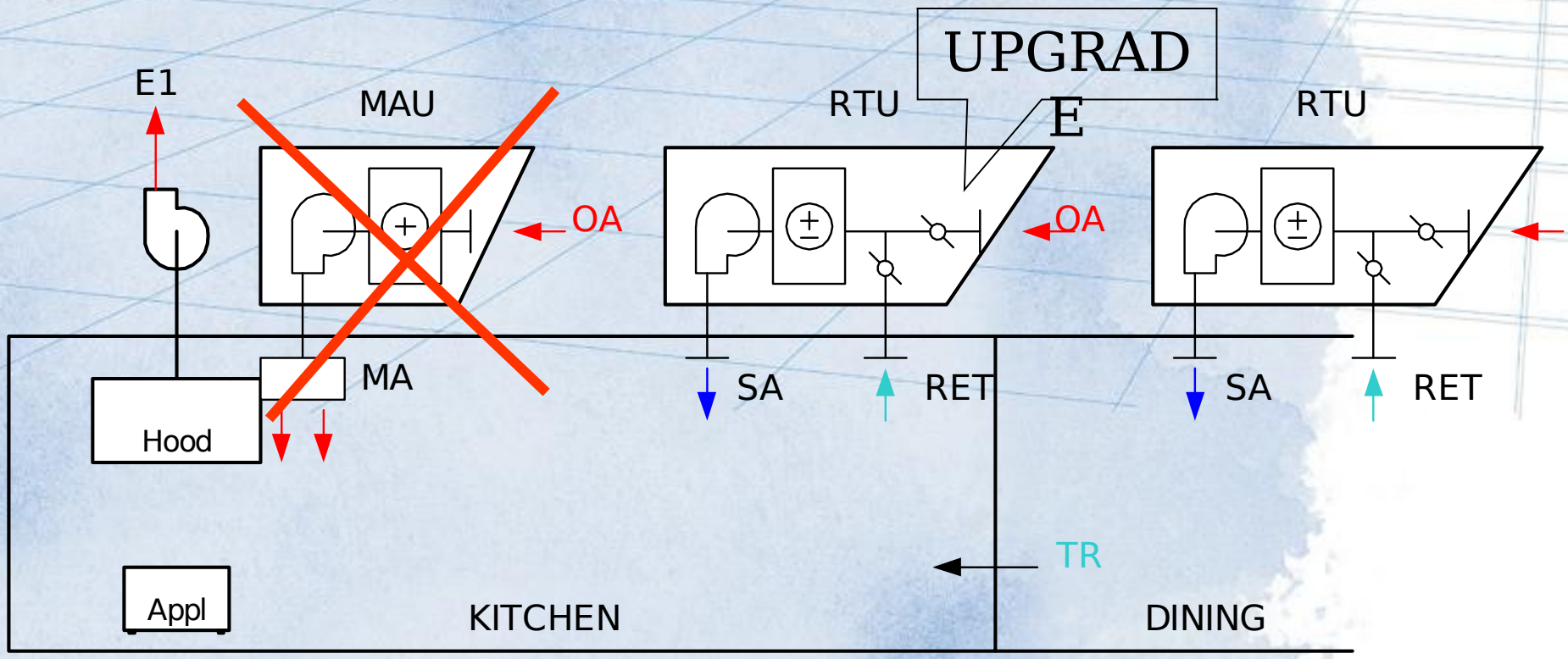
Displacement ventilation, CFD simulation



Total building approach

- **Optimize amount of outside air for the whole building rather than separately for dining room and kitchen**
  - At full occupancy increase amount of OSA to the dining room and maximize transfer air to the kitchen
- **Use demand control ventilation**
  - Hood exhaust airflow as function of appliance status
  - Dining room ventilation as function of occupancy
- **Use a dedicated outside AHU when possible**

Typical restaurant design



Recommendations

- **When the outside temperature is more than 10°F above the kitchen design temperature, make-up air has to be cooled to ensure it does not compromise thermal comfort**
- **Minimize hoods exhaust airflow**
  - Position cooking appliances close to the walls, avoid island installations when possible
  - Enclose appliances with the walls
  - Avoid cross-drafts in kitchen space
  - Use high efficiency, close proximity hoods
- **Switching from mixing ventilation to TDV helps reducing hood exhaust airflow and allows up to a 10°F drop in kitchen space temperature with no additional energy costs**
- **Utilize whole building approach and demand control when designing HVAC system**